

Push Pull Parasite Control From Agriculture To Aquaculture

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Introduction

The push and pull technology is the strategy that has been used for a long period of time. This technique comprises controlling the [agricultural pests](#) that are repellent by the push plants (Pretty and Williams, 2015, p.24). These are also known as trap-pull plants. For instance, if one talks about the cereal crops, such as maize and sorghum, they are often infested by stem borers. What really happens is that the grass that is planted around the perimeter of the crop is attracted by the insects, and the same thing is being used to make sure that the pests are trapped. The technology development was carried out at the International Centre of Insect Physiology and Ecology (Pretty and Williams, 2015, p.24). The Rothamsted Research United Kingdom was the one who assisted during the whole process and was a national partner as well. The approach's main premise is the reliance on the combination of the crops that are supposed to be planted around along the lines of maize and sorghum (Pretty and Williams, 2015, p.24).

Domestic as well as wild grasses can go a long way when it comes to crop protection, as they seem to attract and trap the stem borers (Pretty and Williams, 2015, p.24). The grasses are planted on the border around the maize. What these grasses tend to do is that they allow for the push and pull strategy (Koumoundouros et al. 2016, p.25). The other thing that happens is that they tend to serve as the borers of the natural enemies of the crops. A good trap crop is one that includes well-known grasses such as Napier grass or the infamous Sudan grass. The Napier grass is an important determinant of the way it is being used due to the fact that how the defense against the pests is supposed to be carried out (Hara et al. 2013, p.339). Once they are attacked by the borer larva, they tend to secrete the sticky substance against which the physical traps are being set up. Now, if one talks about the push that is provided by the intercropping of the schemes that are provided by the plants. These plants emit chemicals, and these chemicals tend to repel the stem borer of the moths.

Then, these moths away from the main crop, as well as maize and sorghum, which are the best, can be done in this regard. These plants have repellent properties that are related to the species that are part of the leguminous genus *Desmodium* (Pretty and Williams, 2015, p.24). The *Desmodium* is then planted in between the rows of maize as well as sorghum (Hagiwara et al. 2017, p.223). One of the key things that are involved during the course of the push and pull technology is how the behavior-modifying stimuli are going to be used during the course of the whole process. It talks about the way manipulation of the distribution, as well as the abundance of the stem borers, is supposedly carried out.

There are some beneficial insects as well if one talks about the management of stem borer pests is being carried out (Pretty and Williams, 2015, p.24). These concepts are based on an in-depth understanding of the way chemical ecology is supposed to be shared (Pretty and Williams, 2015, p.24). Then comes some other aspects, such as the way plant and plant or insect-to-plant interactions are supposed to be carried out. Now, if one takes about the way Gravidstemborers are working, what happens is that females are going to be repelled by the main. At the same time, they are also attracted to the trap crop (Pretty and Williams, 2015, p.24). Especially speaking about the Napier grass and the attractive volatile compounds that are trapped due to these plants. There is also an increase of about 100-fold in the total amount for the said time period (Pretty and Williams, 2015, p.24).

The production of these compounds is happening during the nightfall. Especially speaking, the first hour during the course of nightfall is the one that is extremely crucial (Kurokura et al. 2014, p.273). It allows the stem borer to make sure that they are locating the host plants in the appropriate manner (Pretty and Williams, 2015, p.24). Thus, the technique has been deemed very effective when it comes to pest control (Guo et al. 2016, p.19). There is increasing consensus among researchers to make sure that this technique can be used in aquatic animals. The key fact that needs to be taken into consideration is the fact that how food security is going to be provided (Pretty and Williams, 2015, p.24). The push-and-pull parasite control if it is allowing a greater degree of freedom in terms of food security (Guillou et al. 2015, p.351).

The need of the hour is to make sure that for a better aqua climate, the development of new methods is done to ensure that better results can be achieved in terms of aquatic safety (Grima et al. 2014, p.377). The problem is that the way aquatic safety is being compromised these days, there is a need of the hour to make sure that new methods are devised that allow better controls (Kurokura et al. 2014, p.273). Not only the effective utilization of the resources is needed, but bringing about parasite control and making it more effective to the resistance is the key thing that is going to be discussed during the course of this paper (Lavens and Sorgeloos, 2016, p.54). The research is also going to look at the way parasitic behavioral changes might make it more effective to have push and pull control done in some other species (Erdahl et al. 2016, p.341). The key thing that needs to be looked at is to ensure that how the right balance is being achieved in terms of the way controlling mechanism for these plants (Pretty and Williams, 2015, p.24).

Methods And Results

One of the key things that needs to be looked at with respect to the push and pull paradise control is that understanding needs to be developed with regard to the way this technology works (Balmford et al. 2014, p.15). Once the basic understanding of this technology is developed, the next thing that needs to be done is to have an idea of how this technology can be implemented in some other pest control methods (Balmford et al. 2014, p.15). The core essence of this research is whether the push and pull parasite control is going to be effective in the aquatic environment (Balmford et al. 2014,

p.15). The key method that is being used is how the technology is going to be implemented at the larval stage (Balmford et al. 2014, p.15). The problem at the moment is that there is not much innovation with regard to the way maintenance of aquaculture is being done (Balmford et al. 2014, p.15).

The research is going to look at the fact that how it can be made sure that the push and pull method for pest control can be done in the aqua culture bodies as well (Lawrence and Block, 2018, p.65). To do that, it would be seen what are some of the current prevailing methods that are being used for the preservation of aquaculture (Dosdat et al. 2015, p.84). Once that idea is developed, the other phase is going to talk about the fact that how, in the long run, it can be sure that these methods, along with pest control, would also make sure that the overall quality of the water stays the same (Balmford et al. 2014, p.15). The idea is to make sure that some new methods are being devised with regard to better pest control (Phillips and Lardy, 2014, p.404). Along with that, how the method can be used in a manner that is economically viable so that the method can be implemented at much larger. The other thing that is very important is how antibiotic resistance is going to be managed (Balmford et al. 2014, p.15).

Core Methodology Of The Research

The way it works out, the stem borers and other push-and-pull parasite control programs contain certain moths (Pretty et al. 2013, p.234). What is being done is a repellent intercrop is being used, and using that crop, an attractive trap plant is being developed (Pretty et al. 2013, p.234). What happens next is that the insects and other harmful compounds are then repelled from the food crop. Not only that but at the same time, they are also attracted to the trap crop (Pretty et al. 2013, p.234). The basic idea is to ensure that the control of the stem borers is carried out. The advantage that they tend to offer is that they also provide quality fodder to the livestock.

It is a key advantage in terms of the pest management done (Desrosier and Desrosier, 2017, p.4). At the same time, the major concern when using any fertilizer or pest control is what is going to happen to the level of fertility of the soil (Pretty et al., 2013, p.234). Here, there is enough empirical evidence to suggest that the fertility of the soil is not affected due to the way this problem persists most of the time (Ron and Padilla, 2015, p.297). Then comes the chemical composition, and what really happens is disodium is that it provides volatile chemicals (Pretty et al. 2013, p.234). For instance, the production of the (E)- β -cymene and E)-4, 8-dimethyl-1, 3, 7-nonatriene is one of the main reasons due to why they repel the whole thing and the stem borer from the moths to the maize is being made. Then, there is another important consideration about the structure of the grass (Dan et al. 2012, p.115). The Napier grass, for instance, is well known to be octane as well as nominal, naphthalene, 4-allyl anisole, eugenol and linalool, attracting female moths ('pull') to lay eggs. On the other hand, the desmodium roots produce chemicals that tend to stimulate Striga seed germination.

The chemical composition of the germination is going to be 4",5"-dihydro-5,2',4'-trihydroxy-5"-

isopropenylfurano-(2",3";7,6)-isoflavanone, and others which inhibit their attachment to maize roots, such as 4",5"-dihydro-2'-methoxy-5,4'-dihydroxy-5"-isopropenylfurano-(2",3";7,6)-isoflavanone (suicidal germination), and there is a strong likelihood that they are going to reduce the level of toxicity and thus reducing the number of pests that are located in the given area (Cutter and Renwick, 2016, p.3). The functionality of the legumes is such that they tend to improve the fertility of the soil as well. The fertility is being taken care of by making sure that the way nitrogen fixation is supposed to be working out for the said pest treatment method (Pretty et al. 2013, p.234). The way the chemical works, they tend to cause striga to the maize roots as well as bring about the suicidal germination of the seeds as well which goes a long way towards the extermination of these plants (Coser et al. 2013, p.387). Thus, their effectiveness during the course of pest control has already been proven (Pretty et al. 2013, p.234).

The problem is how it is going to make sure that all-around pest control and environmental control can be made possible in the current environment. At the moment, the biggest concern for the people who are looking after the environment is the way pollution is happening in aquaculture (Williams et al. 2012, p.45). As per some estimates, about 90 % production of the aquaculture production is originating from Asia. It is not even exempted from the disease problems (Williams et al. 2012, p.45). This problem is witnessed due to the extreme lengths of intensification that one gets to see these days (Ramgareeb et al., 2014, p.262). The intensification is the culture in which different marine species and large-scale international movements are carried out, which affects aquaculture (Saad et al. 2013, p.133). Not only that, the large-scale international movement that one gets to see these days in terms of the fingerlings and the juveniles is another area where the concern is witnessed in terms of the sustainability of aquaculture (Ramgareeb et al., 2014, p.262). Thus, the core idea of the research is to make sure whether the push and pull technology is good enough to be used in aquaculture, and if not, what are some of the other methods that are needed to be devised to make sure that better degree of control is witnessed in terms of the aquaculture (Ramgareeb et al., 2014, p.262).

Literature Analysis

During the course of this section, it will be seen what the host of the existing literature has to say about the way the preservation of aquaculture is supposed to be carried out (Smith and Onions, 2014, p.2). At the moment, the issue that is being witnessed is that any effort that is being carried out to make sure that the agricultural yield is increased goes against the sustainability of the environment (Ramgareeb et al., 2014, p.262). With the help of push and pull technology, there has been a certain level of success with regard to the way pest control is being achieved in the crop (Stanwood and Bass, 2016, p.54). Despite this fact, though, the major problem that is being faced at the moment is that there is no conclusive evidence that such a technique is going to take care of the problems pertaining to aquaculture (Ramgareeb et al., 2014, p.262). It is very important to make sure that alternative methods and innovation are brought with regard to the way the management of aquaculture is done (Corley and Brandhorst, 2014, p.363). It is due to the fact that the current methods and practices are

not good enough to ensure that these things are being taken care of (Zhang et al. 2013, p.163). Thus it would be interesting to see what are some of the other methods that can be used to ensure sustainable practices are being developed across the board and managing the eco system in an appropriate manner (Zhang et al. 2013, p.163).

Interaction Of The Building Blocks And Conservation Of The Biodiversity

If one talks about the way the management of aquaculture is supposed to be done, the key aspect that the policymakers want to make sure that is that sustainability and the preservation of biodiversity have to be carried out (Raguso et al. 2015, p.617). The other important objective is how the improvement in the local community's livelihood is going to be done (Raguso et al. 2015, p.617). The work that is being done at the moment is to make sure that with the involvement of the local community workers, the MPA management plan is developed.

The key premise of this plan is to make sure that the conservatism and sustainable usage of the way management of biodiversity is carried out during the course of the whole process (Chao et al. 2015, p.406). Not only that, it is also going to include other hosts of activities such as the promotion of aquaculture and ensuring that sufficient awareness about the way aquaculture can be maintained and preserved (Truscott et al. 2018, p.372). To make sure that it happens, the approach that is being used is the value chain approach (Raguso et al. 2015, p.617). With that approach, it is important that the different steps that are carried out during the process of the value chain of aquaculture are being looked after in an appropriate manner. That includes getting all the necessary support from the way strong technical support is needed to be extended (Raguso et al. 2015, p.617). The whole premise of the product is to ensure that there is some sort of involvement from the private sector in this regard (Pickett et al. 2012, p.2).

Carrying out the feasibility analysis, it was shown that if the value chain approach is being used, there is a considerable likelihood that the environmental capacity of the site is going to be improved (Pickett et al. 2012, p.2). That would also make sure that the profit making ability of the business is going to be sustained at a certain level (Pickett et al. 2012, p.2). What is needed here, though, is to make sure that the combined vision is created along with the development of the value chain approach in a manner that becomes sustainable in the long run (Bozkurt and Secer, 2015, p.54). Not only that, with the help of this method, it would ensure that the level of biodiversity that is needed at each and every level of the value chain of aquaculture is going to be taken care of. It all depends, though, on the fact that how the involvement of the private sector is rolling out at the given time period (Pickett et al. 2012, p.2).

Better Understanding Of The Ecological Benefits Of The Aquaculture

The common perception about aquaculture is that it is something that is very beneficial for the long-term ecosystem and the environment. However, there is a need to have a clear distinction in this regard (Bolla et al. 2017, p.374). At the moment, there are several practices that are related to aquaculture that is good for the environment, but on the other hand, practices such as shrimp farming that goes in the mangroves and some other methods have been proven to be quite harmful to the long term environmental sustainability (Bardach et al, 2014, p.44).

Taking the example of the substantial feeding capacity of shellfish aquaculture, what it does is that it adds a substantial filter to the feeding capacity (Pickett et al. 2012, p.2). When that happens, there is always going to be considerable improvement in the quality of the water (Assavaaree et al. 2015, p.39). The extent to which the quality of the water can be improved can be estimated by the fact that how single oyster that can filter about 15 gallons of water has the capacity to remove a considerable number of algae cells that are present in the water (Pickett et al. 2012, p.2). When these cells are being removed, the shellfish then remove the nitrogen as well as some other nutrients from the water (Pickett et al. 2012, p.2). Most of the time, either they are retained or regained, or as this waste is cumulated, it goes towards the bottom of the water (Asahida et al. 2016, p.727).

When the harvest of the shellfish nitrogen is carried out, what happens is that the wastage and other elements that are likely to disrupt the quality of the water are completely removed (Waterfield and Zilberman, 2012, p.223). Thus, the key thing again is the way the value chain is being managed during the course of the whole process. The nutrients such as nitrogen and phosphorus are being directly removed from it (Waterfield and Zilberman, 2012, p.223). When the repacking of these nutrients is carried out, they tend to release atrophic and other nutrient-rich contents (Waterfield and Zilberman, 2012, p.223). These contents are also part of the low dissolved oxygen that is the capacity to disseminate the species. Now this is where the problem occurs, even though there is improvement in the water quality, the issue that is being seen here is that how the biodiversity is affected (Andrade et al. 2015, p.179). It is the dilemma that is being witnessed at the moment with regard to the way aquaculture is likely to affect biodiversity at a given point in time (Waterfield and Zilberman, 2012, p.223).

Ecological Functionality And Aquaculture With Regards To Pest Control

If there is a well developed aquaculture in the area, it is a strong likelihood that it is going to create strong ecological functions that allows the betterment of the inhabitants of that area. For example the shellfish beds and the cages can be used to make sure that the habitat structure is being provided to

the relevant stakeholders over there (Waterfield and Zilberman, 2012, p.223). This structure can then be used to make sure that it provides some sort of shelter to the invertebrates (Waterfield and Zilberman, 2012, p.223). These include small fishes and crustaceans that are potentially increasing from the abundance, as well as making sure that the extent to which the biodiversity is being witnessed in that area (Waterfield and Zilberman, 2012, p.223). When there is increased shelter, it raises the stocks of the way prey fish are supposed to work along with the small crustaceans (Waterfield and Zilberman, 2012, p.223).

What they tend to do is that it provides considerable economic opportunities for the people who are living in those regions. As per some estimates, about 10-meter square of the oyster reef is likely to enhance the biomass of that area by about 3 kg. At the same time, the shellfish that is occurring on the herbivores is also going to be preyed on (Herren et al. 2017, p.65). Due to that, there is a significant shift in the energy level as well as it goes from the primary producers to the higher tropic levels as well as making sure that it is skipping out on the multiple generically costing tropic jumps (Hastie et al. 2014, p.179). These jumps are quite likely to make sure that the increase in biomass is also going to be witnessed in terms of the management of the ecosystem is supposed to be carried out at the given time period. It also goes a long way toward increasing the biomass in the overall ecological system (Cruz-Rivera and Friedlander, 2015, p.218).

Effects Of The Stocking At The Molecular Genetic Level

The case of the natural tilapia diversity in Tanzania stands out, which was a particular hotspot for the people who were living in that area (Waterfield and Zilberman, 2012, p.223). What is needed to be done is the assessment of the effect of the molecular genetics level awareness is carried out with the help of the genomes of the native as well as the stocked forms (Waterfield and Zilberman, 2012, p.223). What is going to be done during the course of the whole process is the recommendations are going to be with regard to the conservation in the in situ and ex situ (Ingvarsdottir et al. 2016, p.537).

These terms are an important determinant of the way pond culture is developed in the area, as well as the way sperm banks are being looked after. Then the estimation of the growth of the pure rates and the hybrid forms is going to be done. Once the assessment is made about the extent to which the environmental proliferation is being carried out in the region, during the next phase, it will be seen how the push and pull technology is going to make sure that the pest control is going to work out in the region (Waterfield and Zilberman, 2012, p.223). The idea behind the case is to make sure that predictions can be made about the implementation of the push and pull technology in these systems and what needs to be done to make sure that the correct mechanism is being developed (Welladsen et al. 2014, p.247). During the course of the research, the ecological niches are also going to be looked at, and it will be seen how the hybrid stains from the stable isotope ratios are going to work out during the course of this given project (Waterfield and Zilberman, 2012, p.223). The key thing that

needs to be taken into consideration is that the end result is going to work out with regard to the effect of the push and pull technology in this case (Johnstone et al. 2013, p.98).

Effects Of The Push And Pull Technology In The Aquaculture

There is a considerable difference when it comes to making sure that the relevant pest control is achieved in the agricultural context as compared to witnessing the same thing in aquaculture (Waterfield and Zilberman, 2012, p.223). The results from the research were mixed, to say the least. One of the first things that was seen was that when the successful was carried out in the aquaculture, the results were initially encouraging. What happened was that there was considerable forage if one talks about the overall soil quality as well as the way fertility of the soil was concerned (Waterfield and Zilberman, 2012, p.223). At the same time, when the widespread implementation was carried out, the other major impact that the attract repel plant system was developed in the aquaculture that allowed a greater degree of control in terms of the way underwater species were supposed to be surviving (Waterfield and Zilberman, 2012, p.223).

The key thing that needed to be done was how the intercropping was done at this level, and the result was imminent, which was how the whole thing was repelled in the given time period. The development of the decoy plants and the protection from crop infestation was witnessed during the same time period (Nelson et al. 2014, p.57). The combination that worked out well in terms of the intercropping was the maize and some other additional repelling plants that were working at the initial working plant borers (Nelson et al. 2014, p.57). The other important result that was achieved was that how there was an apparent reduction in the density of the stem borer. There was an enhancement in the parasitism rates (Romney et al. 2013, p.31). Thus, if the intercropping is done in the appropriate manner, it would allow better pest control at each level. The major problem, though, was the fact that how the biodiversity was supposed to be managed.

There are many living organisms that are very important for the water quality and the eventual survival of the species that are located in the water (Nelson et al. 2014, p.57). When pest control is carried out at such an extensive level, the likelihood is that it is going to disrupt living organisms, that are important in terms of the way ecological and environmental effects of aquaculture are supposed to be carried out (Nelson et al. 2014, p.57). The push-and-pull technology is bringing down the level of water quality (Nelson et al. 2014, p.57). What is happening at the moment is that due to the at the moment, the technology has still not reached the phase where the multiple plant species are specifically going to make sure that they are going to bring about the element of control that is needed to allow for better system development (Nelson et al. 2014, p.57).

One idea that is floated is how the attractant plants need to be developed to make sure that the effective trap crops that are going to exterminate only those plants that are going to have an effect on the overall longevity of the plant (Nelson et al. 2014, p.57). Another method that can be used is to

make sure that the appropriate intercropping is carried out in a manner that allows the relevant stem borer at the mortality level and reduces the crop losses for the given time period (Nelson et al. 2014, p.57). It has to be noted that initial results are encouraging enough to make sure that one can go ahead with future research in this regard and come up with the right permutation in terms of the intercropping so that not only pest control is being done, but also it can be made sure that the biodiversity in terms of the aquaculture can be maintained (Nelson et al. 2014, p.57).

Conclusion And Consideration For Future Research

Out of all the recent technologies that are being developed with regard to pest control, push and pull control is something that brings about the control mechanism. Not only it has been well known to make sure that it has brought about the required pest control, it has also made sure that how the overall quality of the soil is being looked after (Pretty and Bharucha, 2014, p.65). There are about 17 species of stem borers that have been found to be effective with regard to pest control (Pretty and Bharucha, 2014, p.65). The reason that this technology has been used at an extensive level in agriculture is due to the fact that how the crop culliver and agricultural yield are not affected due to the whole process (Pretty and Bharucha, 2014, p.65). The element of pest control has reached as high as 80 % in the concerned areas.

Looking at its relative success in agriculture, combined with the concerns about aquaculture, has prompted researchers to foresee how push and pull technology can be used in aquaculture (Pretty and Bharucha, 2014, p.65). Especially after the recent cases when parasites and other living organisms have caused considerable damage to aquaculture. The concerns are justified due to the fact that despite the advantages of aquaculture, and in general, the practice has been well received with regards to bringing about the improvement in biodiversity; at the same time, the way aquaculture systems are working at the moment, there are significant environmental impacts. Especially if the aquaculture is carried out in the inland waters (Pretty and Bharucha, 2014, p.65). If the whole activity is carried out in the inland waters, it is also likely to damage the wild fisheries as well (Pretty and Bharucha, 2014, p.65). Even though the practice is carried out in the manner that waste management is looked after, there are some other concerns that need to be looked at with regard to the value chain (Kumar et al. 2013, p.50).

There are many ways through which the pest control mechanism can be developed as well as making sure that the biodiversity that is one of the defining features of the aqua climate is being seen (Pretty and Bharucha, 2014, p.65). At the moment, the effort is being made to make sure that the improvement is being brought with regards to the value chain system of the aquaculture is being carried out. The development of the aquatic food webs is another area where improvement can be brought about at a great level (Pretty and Bharucha, 2014, p.65). The element of control that needs to be brought with regard to the stakeholders is another approach that can be brought upon. Even though the amendment in the value chain would go a long way towards making sure that the whole thing can be improved (Pretty and Bharucha, 2014, p.65), this solution would also make sure that the

extent to which biodiversity is not going to be affected during the course of the whole process (Pretty and Bharucha, 2014, p.65).

The cost and benefit analysis implies that such a practice is going to be very costly, and without the involvement of the private sector and investors, such an effort would be futile as the exercise needs to be implemented at a larger scale (Sassenrath et al. 2016, p.285). As far as the push and pull technology is concerned for the management of pests in aquaculture. The initial reports and results have been encouraging in this regard. It has been witnessed that when the intercropping is done even at the basic level, not only does it ensure that the relevant pest control is being achieved, but it is something that is sustainable in the sense that the quality of the water samples was not affected when the relevant technology was being implemented. The only major problem that is emerging at the moment is how biodiversity is going to be affected due to the whole thing (Khan et al. 2015, p.76). One of the defining aspects of aquaculture is that biodiversity has to be sustained as it has long-term implications for water quality. There are economic implications as well that need to be kept in mind (Sassenrath et al. 2016, p.285). There is scope for future research, though, regarding how intercropping can be done to make sure that a better element of control is being witnessed and the right sort of permutation is developed in terms of intercropping (Sassenrath et al. 2016, p.285).

References

- Andrade, T.P., Redman, R.M. and Lightner, D.V., 2015. Evaluation of the preservation of shrimp samples with Davidson's AFA fixative for infectious myonecrosis virus (IMNV) in situ hybridization. *Aquaculture*, 278(1-4), pp.179-183.
- Asahida, T., Kobayashi, T., Saitoh, K. and Nakayama, I., 2016. Tissue preservation and total DNA extraction from fish stored at ambient temperature using buffers containing high concentration of urea. *Fisheries science*, 62(5), pp.727-730.
- Assavaaree, M., Hagiwara, A., Ide, K., Maruyama, K. and Lubzens, E., 2015. Low-temperature preservation (at 4° C) of marine rotifer *Brachionus*. *Aquaculture Research*, 32(1), pp.29-39.
- Balmford, A., Green, R. and Phalan, B., 2014. What conservationists need to know about farming. *Proc. R. Soc. B*, p.rspb20120515.
- Bardach, J.E., Ryther, J.H. and McLarney, W.O., 2014. *Aquaculture. The farming and husbandry of freshwater and marine organisms*. John Wiley & Sons, Inc..
- Bolla, S., Holmefjord, I. and Refstie, T., 2017. Cryogenic preservation of Atlantic halibut sperm. *Aquaculture*, 65(3-4), pp.371-374.
- Bozkurt, Y. and Secer, S., 2015. Effect of short-term preservation of mirror carp (*Cyprinus carpio*) semen on motility, fertilization, and hatching rates.

- Chao, N.H., Chen, H.P. and Liao, I.C., 2015. Study on cryogenic preservation of grey mullet sperm. *Aquaculture*, 5(4), pp.389-406.
- Corley-Smith, G.E. and Brandhorst, B.P., 2014. Preservation of endangered species and populations: a role for genome banking, somatic cell cloning, and androgenesis?. *Molecular reproduction and development*, 53(3), pp.363-367.
- Coser, A.M., Godinho, H. and Ribeiro, D., 2013. Cryogenic preservation of spermatozoa from *Prochilodus scrofa* and *Salminus maxillosus*. *Aquaculture*, 37(4), pp.387-390.
- Cruz-Rivera, E. and Friedlander, M., 2015. Feeding preferences of mesograzers on aquacultured *Gracilaria* and sympatric algae. *Aquaculture*, 322, pp.218-222.
- Cutter, S.L. and Renwick, W.H., 2016. *Exploitation, conservation, preservation: a geographic perspective on natural resource use* (No. Ed. 3). John Wiley and Sons.
- Dan, X.M., Lin, X.T., Yan, Y.X., Teng, N., Tan, Z.L. and Li, A.X., 2012. A technique for the preservation of *Cryptocaryon irritans* at low temperatures. *Aquaculture*, 297(1-4), pp.112-115.
- Desrosier, N.W. and Desrosier, J.N., 2017. *The technology of food preservation* (No. Ed. 4). AVI Publishing Company, Inc..
- Dosdat, A., Gaumet, F. and Chartois, H., 2015. Marine aquaculture effluent monitoring: methodological approach to the evaluation of nitrogen and phosphorus excretion by fish. *Aquacultural Engineering*, 14(1), pp.59-84.
- Erdahl, A.W., Erdahl, D.A. and Graham, E.F., 2016. Some factors affecting the preservation of salmonid spermatozoa. *Aquaculture*, 43(1-3), pp.341-350.
- Grima, E.M., Pérez, J.S., Camacho, F.G., Fernández, F.A., Alonso, D.L. and Del Castillo, C.S., 2014. Preservation of the marine microalga, *Isochrysis galbana*: influence on the fatty acid profile. *Aquaculture*, 123(3-4), pp.377-385.
- Guillou, A., Khalil, M. and Adambounou, L., 2015. Effects of silage preservation on astaxanthin forms and fatty acid profiles of processed shrimp (*Pandalus borealis*) waste. *Aquaculture*, 130(4), pp.351-360.
- Guo, X., Ford, S.E. and Zhang, F., 2016. Molluscan aquaculture in China. *Journal of Shellfish Research*, 18(1), pp.19-31.
- Hagiwara, A., Balompapueng, M.D., Munuswamy, N. and Hirayama, K., 2017. Mass production and preservation of the resting eggs of the euryhaline rotifer *Brachionus plicatilis* and *B. rotundiformis*. *Aquaculture*, 155(1-4), pp.223-230.

- Hara, S., Canto Jr, J.T. and Almendras, J.M., 2013. A comparative study of various extenders for milkfish, *Chanos chanos* (Forsskål), sperm preservation. *Aquaculture*, 28(3-4), pp.339-346.
- Hastie, L.C., Wallace, C., Birkett, M.A., Douglas, A., Jones, O., Mordue, A.J., Ritchie, G., Pickett, J.A., Webster, J.L. and Bowman, A.S., 2014. Prevalence and infection intensity of sea lice (*Lepeophtheirus salmonis*) on Atlantic salmon (*Salmo salar*) host is reduced by the non-host compound 2-aminoacetophenone. *Aquaculture*, 410, pp.179-183.
- Herren, H.R., Bassi, A.M., Tan, Z. and Binns, W.P., 2017. Green jobs for a revitalized food and agriculture sector. *Nature Resources Management and Environment Department, Food and Agriculture Organization of the United Nations, Rome*.
- Ingvarsdottir, A., Birkett, M.A., Duce, I., Genna, R.L., Mordue, W., Pickett, J.A. and Wadhams, L.J., 2016. Semiochemical strategies for sea louse control: host location cues. *Pest management science*, 58(6), pp.537-545.
- Johnstone, R.T., 2013. Occupational Diseases. Diagnosis, Medicolegal Aspects and Treatment. *Occupational Diseases. Diagnosis, Medicolegal Aspects and Treatment*.
- Khan, Z.R., Pickett, J.A., Hamilton, M.L., Hassanali, A., Hooper, A.M., Kuate, S.P., Midega, C.A.O., Pittchar, J. and Torto, B., 2015. Control of stem borers and Striga in African cereals: a low input push-pull approach with rapidly expanding impact. *Aspects of Applied Biology*, (96), pp.71-76.
- Koumoundouros, G., Divanach, P., Savaki, A. and Kentouri, M., 2016. Effects of three preservation methods on the evolution of swimbladder radiographic appearance in sea bass and sea bream juveniles. *Aquaculture*, 182(1-2), pp.17-25.
- Kumar, V.J.F., Durairaj, C.D. and Salokhe, V.M., 2013. Ergonomic evaluation of hand weeder operation using simulated actuary motion. *International Agricultural Engineering Journal*, 9(1), pp.41-50.
- Kurokura, H., Hirano, R., Tomita, M. and Iwahashi, M., 2014. Cryopreservation of carp sperm. *Aquaculture*, 37(3), pp.267-273.
- Lavens, P. and Sorgeloos, P., 2016. *Manual on the production and use of live food for aquaculture* (No. 361). Food and Agriculture Organization (FAO)..
- Lawrence, C.A. and Block, S.S., 2018. Disinfection, sterilization, and preservation. *Disinfection, sterilization, and preservation*.
- Nelson, K.C., Kibata, G., Muhammad, L., Okuro, J.O., Muyekho, F., Odindo, M., Ely, A. and Waquil, J.M., 2014. Problem formulation and options assessment (PFOA) for genetically modified organisms: the Kenya case study. *Environmental risk assessment of genetically modified organisms*, 1, pp.57-82.
- Phillips, P.H. and Lardy, H.A., 2014. A yolk-buffer pabulum for the preservation of bull sperm. *Journal*

of Dairy Science, 23, pp.399-404.

Pickett, J.A., ARADOTTIR, G.I., Birkett, M.A., Bruce, T.J., Chamberlain, K., Khan, Z.R., Midega, C.A., Smart, L.E. and Woodcock, C.M., 2012. Aspects of insect chemical ecology: exploitation of reception and detection as tools for deception of pests and beneficial insects. *Physiological Entomology*, 37(1), pp.2-9.

Pretty, J. and Bharucha, Z.P., 2014. Sustainable intensification in agricultural systems. *Annals of Botany*, 114(8), pp.1571-1596.

Pretty, J., Toulmin, C. and Williams, S., 2015. Sustainable intensification in African agriculture. *International journal of agricultural sustainability*, 9(1), pp.5-24.

Pretty, J.N., Morison, J.I. and Hine, R.E., 2013. Reducing food poverty by increasing agricultural sustainability in developing countries. *Agriculture, ecosystems & environment*, 95(1), pp.217-234.

Raguso, R.A., Agrawal, A.A., Douglas, A.E., Jander, G., Kessler, A., Poveda, K. and Thaler, J.S., 2015. The raison d'être of chemical ecology. *Ecology*, 96(3), pp.617-630.

Ramgareeb, S., McFarlane, S.A., Conlong, D.E. and Rutherford, R.S., 2014. Identification of herbivore induced plant volatiles from push-pull plants and Fusarium species: aids for the management of *Eldana saccharina* Walker (Lepidoptera: Pyralidae) in sugarcane?. In *Proceedings of the Annual Congress-South African Sugar Technologists' Association* (No. 83, pp. 262-266). South African Sugar Technologists' Association.

Romney, D., Day, R., Faheem, M., Finegold, C., LaMontagne-Godwin, J. and Negussie, E., 2013. Plantwise: putting innovation systems principles into practice. *Agriculture for Development*, (18), pp.27-31.

Ron, J. and Padilla, J.E., 2015. Preservation or conversion? Valuation and evaluation of a mangrove forest in the Philippines. *Environmental and Resource Economics*, 14(3), pp.297-331.

Saad, A., Billard, R., Theron, M.C. and Hollebecq, M.G., 2013. Short-term preservation of carp (*Cyprinus carpio*) semen. *Aquaculture*, 71(1-2), pp.133-150.

Sassenrath, G.F., Heilman, P., Luschei, E., Bennett, G.L., Fitzgerald, G., Klesius, P., Tracy, W., Williford, J.R. and Zimba, P.V., 2016. Technology, complexity and change in agricultural production systems. *Renewable Agriculture and Food Systems*, 23(4), pp.285-295.

Smith, D. and Onions, A.H., 2014. *The preservation and maintenance of living fungi* (No. Ed. 2). CAB international.

Stanwood, P.C. and Bass, L.N., 2016. Seed germplasm preservation using liquid nitrogen. *Seed Science and Technology (Netherlands)*.

Truscott, B., Idler, D.R., Hoyle, R.J. and Freeman, H.C., 2018. Sub-zero preservation of Atlantic salmon sperm. *Journal of the Fisheries Board of Canada*, 25(2), pp.363-372.

Waterfield, G. and Zilberman, D., 2012. Pest management in food systems: an economic perspective. *Annual Review of Environment and Resources*, 37, pp.223-245.

Welladsen, H., Kent, M., Mangott, A. and Li, Y., 2014. Shelf-life assessment of microalgae concentrates: effect of cold preservation on microalgal nutrition profiles. *Aquaculture*, 430, pp.241-247.

Williams, S., Toulmin, C. and Pretty, J.N., 2012. *Sustainable intensification: increasing productivity in African food and agricultural systems*. Routledge.

Zhang, J., Shen, G. and Yang, B., 2013. Design and implementation of information service system for rural science and technology based on push-and-pull technology. *Guizhou Agricultural Sciences*, (2), pp.161-163.